PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
C09C 1/02, D21H 17/63, 17/64, 17/65, 17/67

A1

(11) International Publication Number: WO 97/14755

(43) International Publication Date: 24 April 1997 (24.04.97)

(21) International Application Number: PCT/US96/16633

(22) International Filing Date: 18 October 1996 (18.10.96)

(30) Priority Data:
08/546,222 20 October 1995 (20.10.95) US

(71) Applicant: ECC INTERNATIONAL INC. [US/US]; Suite 300, 100 Mansell Court East, Roswell, GA 30076 (US).

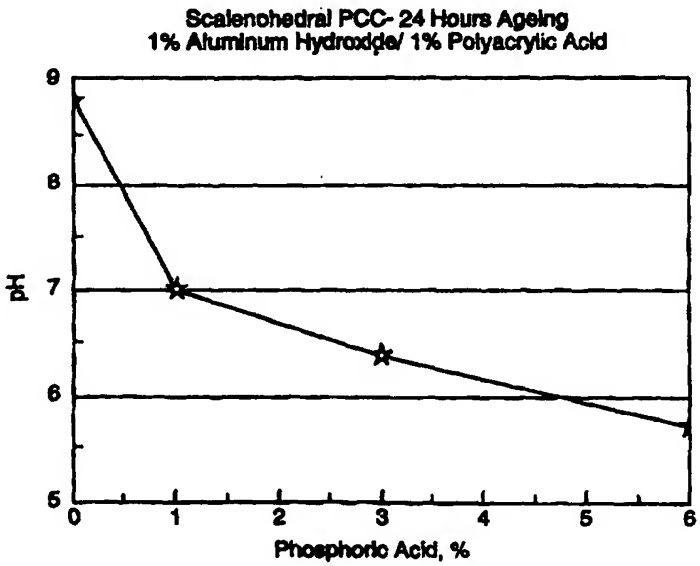
(72) Inventor: WU, Kuan-Ting; 620 Harrison Street, Sandersville, GA 31082 (US).

(74) Agent: KIKEL, Suzanne; ECC International Inc., Calgon Center, 5400 Campbells Run Road, Pittsburgh, PA 15205-1084 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: ACID RESISTANT CARBONATE COMPOSITION CONTAINING AN ALUMINUM OR MAGNESIUM HYDROXIDE AND USES THEREFOR



(57) Abstract

An improved form of calcium carbonate which is acid resistant to enable its use as a filler material in the making of neutral to weakly acid paper, and a process for producing this acid resistant calcium carbonate are provided. This acid resistant calcium carbonate comprises a mixture of at least about 0.1 percent, based on the dry weight of the calcium carbonate, of an aluminum or magnesium hydroxide, together with at least about 0.1 percent, based on the dry weight of the calcium carbonate, of a mixture of weak acids in admixture with the calcium carbonate.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgystan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SG	Singapore
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LR	Liberia	SZ	Swaziland
CS	Czechoslovakia	LT	Lithuania	TD	Chad
CZ	Czech Republic	LU	Luxembourg	TG	Togo
DE	Germany	LV	Latvia	TJ	Tajikistan
DK	Denmark	MC	Monaco	TT	Trinidad and Tobago
EE	Estonia	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	UG	Uganda
FI	Finland	ML	Mali	US	United States of America
FR	France	MN	Mongolia	UZ	Uzbekistan
GA	Gabon	MR	Mauritania	VN	Viet Nam

ACID RESISTANT CARBONATE COMPOSITION CONTAINING AN ALUMINUM OR MAGNESIUM HYDROXIDE AND USES THEREFOR

BACKGROUND OF THE INVENTION

This invention relates generally to calcium carbonate for use in papermaking, and related industries, and more particularly to a calcium carbonate having acid resistant properties.

Titanium dioxide and calcined clay have traditionally been utilized as filler materials in the preparation of neutral to weakly acidic paper in order to improve the optical properties, especially the brightness, of the resultant product. These materials, however, especially titanium dioxide, have the disadvantage of being very expensive, resulting in higher manufacturing costs and an uncompetitively priced paper product.

Calcium carbonate, particularly precipitated calcium carbonate, has been used as a filler material in the making of alkaline paper. Such usage results in a paper with enhanced optical properties, without the expense incurred in using titanium oxide fillers, resulting in a much less expensive product. Calcium carbonate, however, cannot generally be used as a filler in acidic paper because it decomposes in an acidic environment. Consequently, there has long been a need to develop a calcium carbonate composition which is acid stabilized and resistant to decomposition at low pH, so that it can be utilized as a filler material in the manufacture of acidic paper, such as groundwood paper, where the use of an alkaline filler would have a negative impact on the final paper properties.

Paper made from mechanical pulps has been traditionally produced under acidic papermaking conditions because of "fiber alkaline darkening" that occurs as pH rises. This means that there is a reduction

in brightness of the paper (brightness reversion) when the pH is raised from acid to alkaline in wood-containing systems. Alkaline darkening will occur to some degree in any wood pulps with significant lignin content. The degree of darkening depends on the particular pulps, pH, and water quality. In general, ground calcium carbonate and precipitated calcium carbonate fillers buffer wet end in the 7.5-8.2 pH range. Acid-resistant calcium carbonate compositions thus provide a means for reducing the degree of fiber alkaline darkening and brightness reversion due to their ability to maintain a stabilized pH.

U. S. Patent 5,043,017, (June Passaretti, assigned to Pfizer, Inc.) discloses and claims an acid-stable calcium carbonate resistant to degradation in a mildly acidic environment which comprises a mixture of a calcium-chelating agent or a conjugate base, and a weak acid, such that calcium carbonate is coated by, and is in equilibrium with, the calcium-chelating agent or conjugate base and the weak acid. Preferred calcium carbonate compositions shown in this disclosure are compositions containing sodium hexametaphosphate and phosphoric acid.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide stabilized and acid resistant calcium carbonate compositions especially suitable for use in papermaking applications. These stabilized and acid resistant calcium carbonate compositions contain in addition to the calcium carbonate, an aluminum or magnesium hydroxide, together with a mixture of two or more weak acids.

It is a further object of the present invention to provide a process for the preparation of the aforesaid calcium carbonate compositions.

A still further object of the present invention is to provide a paper having enhanced optical qualities prepared using the calcium carbonate compositions of the present invention.

SUMMARY OF THE INVENTION

The present invention relates to an improved form of calcium carbonate which is stabilized and thus, acid resistant, to enable its use as a filler material in the making of neutral to weakly acid paper, and a process for producing this acid resistant calcium carbonate. More particularly, this invention concerns an acid resistant calcium carbonate comprising a mixture of at least about 0.1 percent, based on the dry weight of the calcium carbonate, of an aluminum or magnesium hydroxide together with at least about 0.1 percent, based on the dry weight of the calcium carbonate, of a mixture of two or more weak acids, in admixture with the calcium carbonate. It has surprisingly been found that the inclusion of the aluminum or magnesium hydroxide and the mixture of two or more weak acids confers a higher degree of stability and acid resistance for calcium carbonate in the presence of fiber slurry, and a longer term of pH stability than the prior art acid-stabilized calcium carbonate compositions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a graph comparing the 24 hours ageing of scalenohedral precipitated calcium carbonate compositions of the present invention containing 1% aluminum hydroxide, 1% polyacrylate acid and various concentrations of phosphoric acid.

FIGURE 2 is a graph comparing the pH of a scalenohedral precipitated calcium carbonate composition of the present invention containing 1% aluminum hydroxide, 1% polyacrylate acid, and 6% phosphoric acid to the pH of a composition of the prior art which contains 1% sodium hexametaphosphate and 7% phosphoric

acid.

FIGURE 3 is a graph showing the pH of ground calcium carbonate compositions of the present invention which contain 3% aluminum hydroxide/1% polyacrylate acid/6% phosphoric acid, or 5% aluminum hydroxide/1% polyacrylate acid/6% phosphoric acid.

FIGURE 4 is a graph showing the pH of rhombic precipitated calcium carbonate compositions of the present invention containing 0.5% magnesium carbonate hydroxide/1% polyacrylate acid/1% phosphoric acid, 0.5% magnesium carbonate hydroxide/1% polyacrylate acid/3% phosphoric acid, or 0.5% magnesium carbonate hydroxide/1% polyacrylate acid/6% phosphoric acid.

FIGURE 5 is a graph comparing the pH of ground calcium carbonate compositions containing 1% magnesium hydroxide/1% polyacrylate acid/2% phosphoric acid, 1% magnesium hydroxide/1% polyacrylate acid/4% phosphoric acid, or 1% magnesium hydroxide/1% polyacrylate acid/6% phosphoric acid.

FIGURE 6 is a graph comparing the pH of ground calcium carbonate compositions containing 1% aluminum hydroxide/3% polymaleic acid/1% phosphoric acid, 0.5% magnesium hydroxide/3% polymaleic acid/1% phosphoric acid, or 1% magnesium carbonate hydroxide/3% polymaleic acid/1% phosphoric acid.

DETAILED DESCRIPTION OF THE INVENTION

The improved form of calcium carbonate prepared by the instant invention is stabilized, and thus, acid resistant, to enable its use as a filler material in the making of neutral to weakly acid paper. While not wishing to be bound by any particular theory as to the operability of the present invention, it is believed that the acid resistance conferred upon the calcium carbonate compositions of the present invention is a result of the inactivation of the surface of the calcium carbonate by

the addition of the magnesium or aluminum hydroxide and the mixtures of the two weak acids.

In the practice of the present invention, the calcium carbonate compositions are rendered acid resistant by the inclusion of at least about 0.1 percent, based on the dry weight of the calcium carbonate, of an aluminum or magnesium hydroxide, together with at least about 0.1 percent, based on the dry weight of the calcium carbonate, of a mixture of two or more weak acids. Especially preferred as one component of the mixture of weak acids is an organic, polymeric weak acid, such as polyacrylate or polymaleic acid.

While not wishing to be bound by any theory, it is believed that the capability of the acid-stabilized calcium carbonate of the present invention to resist dissociation in an acidic environment is due to the polymer adsorption on the surface of the calcium carbonate, absorption of polymer functional groups on the calcium carbonate surface, and the formation of a buffering system between anionic functional groups of the polymer and a weak acid, or the polymeric acid and the aluminum or magnesium hydroxide. This mechanism of polymer adsorption is distinct from absorption or reaction of the prior art sodium hexametaphosphate on the surface of calcium carbonate. Polymer adsorption can provide a barrier coating on the surface of calcium carbonate which reduces the dissolution reaction of calcium carbonate. On the other hand, the absorption or reaction of sodium hexametaphosphate is limited to the surface of the calcium carbonate.

The hydroxides of aluminum or magnesium utilized in the compositions of the present invention include the various salt forms, either hydrated or unhydrated, such as aluminum hydroxide, magnesium hydroxide, and magnesium carbonate hydroxide. The amount of the aluminum or

magnesium hydroxide utilized is at least 0.1 percent, based on the dry weight of the calcium carbonate, and is preferably about 1 to about 6 percent, based on the dry weight of calcium carbonate.

The weak acids utilized in the compositions of the present invention are preferably weak acids selected from the group consisting of phosphoric acid, metaphosphoric acid, hexametaphosphoric acid, ethylenediaminetetraacetic acid (EDTA), citric acid, sulfurous acid, boric acid, acetic acid and weak acids derived from organic polymeric acids, such as polyacrylate acid, polymaleic acid and polycarboxylic acid. As noted hereinbefore, the mixture of weak acids preferably contains at least one weak acid which is derived from an organic, polymeric acid. These organic polymeric acids are typically an organic polymer having a weight average molecular weight, M_w, in the range of 750-1,000,000, consisting of regularly repeating units or chemically similar units, connected by primary covalent bonds. The total amount of the weak acids utilized is at least 0.1 percent, based on the dry weight of the calcium carbonate, and is preferably about 1 to about 8 percent, based on the dry weight of the calcium carbonate.

Preferred combinations of the hydroxides of aluminum or magnesium with weak acids for use in the present invention include aluminum hydroxide/polyacrylate acid/phosphoric acid, magnesium carbonate hydroxide/polyacrylate acid/phosphoric acid, aluminum hydroxide/polymaleic acid/phosphoric acid, magnesium hydroxide/polymaleic acid/phosphoric acid, and magnesium carbonate hydroxide/polymaleic acid/phosphoric acid.

The calcium carbonate utilized is preferably finely divided and it can be either a precipitated calcium carbonate or a natural ground limestone.

The process for producing this acid resistant calcium carbonate involves first forming a mixture of calcium carbonate with at least about 0.1 percent, based on the dry weight of the calcium carbonate, of the aluminum or magnesium hydroxide to be utilized. Then, at least about 0.1 percent, based on the dry weight of the calcium carbonate, of the mixture of weak acids is added to this resultant mixture. Finally, the resultant mixture is blended for a sufficiently long period of time to ensure uniform mixing of the ingredients.

The calcium carbonate can be utilized in the above-described process either as a dry powder or an aqueous slurry with up to about 60 percent by weight solids content.

The aluminum or magnesium hydroxide can be utilized in the instant process either as a dry solid or as an aqueous suspension. When the calcium carbonate is used in dry powder form, it is preferable to utilize an aqueous suspension of the aluminum hydroxide in order to facilitate homogeneous mixing. Where a slurry of the calcium carbonate is utilized, the solid form of the magnesium or aluminum hydroxide will disperse itself therein so that an aqueous suspension is unnecessary.

The weak acids can be utilized in the process of preparation in either pure concentrated forms or as aqueous solutions. In a preferred embodiment of the instant process, the aluminum hydroxide or magnesium hydroxide is first added to the calcium carbonate, and then, one of the polymeric acids or phosphoric acid, and finally, the second acid. Alternately, the aluminum or magnesium hydroxide, polymeric acid, and phosphoric acid can be added at the same time, or the aluminum or magnesium hydroxide, polymeric acid, and phosphoric acid can be mixed and then added to the calcium carbonate.

The composition of the present invention can be utilized to improve the optical properties of neutral to weakly acidic paper by its addition to the paper during standard manufacturing processes. Typically, the calcium carbonate composition of the present invention is added to a first paper furnish containing components necessary for making acidic paper to thereby form a second paper furnish.

The invention will be further illustrated by the following Examples, which are to be considered illustrative of the invention, and not limited to the precise embodiments shown.

EXAMPLE 1

Scalenohedral Precipitated Calcium Carbonate

Acid stabilized scalenohedral precipitated calcium carbonate slurry can be obtained by the addition of an aluminum hydroxide, followed by the addition of a mixture of weak acids such as phosphoric acid and a polymeric acid such as a polyacrylate acid. Initially, 1% aluminum hydroxide, based on the dry weight of calcium carbonate, was added into 19.7% solids slurry of scalenohedral precipitated calcium carbonate. The pH of untreated scalenohedral precipitated calcium carbonate slurry was 8.83. After mixing, 1-6% phosphoric acid and 1% polyacrylate acid, based on the dry weight of calcium carbonate, were added. A plot of the pH was measured for each sample after 24 hours ageing is as shown in Figure 1. A calcium carbonate composition, containing 1% aluminum hydroxide, based on the dry weight of calcium carbonate, and 6% phosphoric acid and 1% of polyacrylate acid, based on dry weight of calcium carbonate was found to have an initial pH 4.97. After 24 hours ageing the pH was remeasured and found to be 5.73. A comparison composition containing 1% sodium hexametaphosphate, based on the dry weight of calcium carbonate and 7% phosphoric

acid, based on the dry weight of calcium carbonate, was similarly prepared and found to have an initial pH of 4.96, and a pH of 5.94 after 24 hours ageing as shown graphically in Figure 2. The pH of the composition of the present invention thus has 0.21 unit less than that of the prior art composition containing sodium hexametaphosphate and phosphoric acid. Thus the composition of the present invention has higher acid stability.

EXAMPLE 2

Ground Calcium Carbonate

The initial pH of ground calcium carbonate was 8.01. Initially, 3% or 5% aluminum hydroxide, based on the dry weight of calcium carbonate, was added into a 20% solids slurry of ground calcium carbonate. After blending, 6% phosphoric acid and 1% polyacrylate acid, based on the dry weight of calcium carbonate, were added. The initial pH of the slurry with 3% aluminum hydroxide/6%H_3PO_4/1% polyacrylate acid treatment was measured and found to be 4.63, which rose to a pH of 4.98 after 30 hours ageing as shown graphically in Figure 3.

EXAMPLE 3

Rhombic Precipitated Calcium Carbonate

Acid stabilized rhombic precipitated calcium carbonate slurry can be obtained by the addition of magnesium carbonate hydroxide [$MgCO_3 \cdot Mg(OH)_2$], followed by the addition of a weak acid such as phosphoric acid and a polymeric acid such as polyacrylate acid. Initially, 0.5% magnesium carbonate hydroxide, based on the dry weight of calcium carbonate, was added into 18.2% solids slurry of rhombic precipitated calcium carbonate. The pH of untreated rhombic precipitated calcium carbonate slurry was 8.79. After mixing, 1-6% phosphoric acid and 1% polyacrylate acid, based on the dry weight of calcium carbonate, were added. A plot of the pH was measured for

each sample within 90 hours ageing as shown in Figure 4. A composition containing 0.5% magnesium carbonate hydroxide, based on the dry weight of calcium carbonate, and 6% phosphoric acid and 1% of polyacrylate acid, based on the dry weight of calcium carbonate was found to have an initial pH of the slurry of 5.00, which resulted in a pH=6.18, after 90 hours ageing.

EXAMPLE 4

Ground Calcium Carbonate

Acid stabilized ground calcium carbonate slurry can be obtained by the addition of magnesium hydroxide, followed by the addition of a weak acid such as phosphoric acid and a polymeric acid such as polyacrylate acid. Initially, 1% magnesium hydroxide, based on the dry weight of calcium carbonate, was added into a 20% solids slurry of ground calcium carbonate. The initial pH of calcium carbonate slurry was 8.01. After mixing, 2-6% phosphoric acid and 1% polyacrylate acid, based on the dry weight of calcium carbonate, was added. A plot of pH was measured for each sample after 31 hours ageing as shown graphically in Figure 5. A composition containing 1% magnesium hydroxide, based on the dry weight of calcium carbonate, and 4% phosphoric acid and 1% of polyacrylate acid, based on the dry weight of calcium carbonate was found to have an initial pH of 5.48, and, after 31 hours ageing, a pH of 6.07.

EXAMPLE 5

Ground Calcium Carbonate

Acid stabilized ground calcium carbonate slurry can be obtained by the addition of aluminum hydroxide, magnesium hydroxide or magnesium carbonate hydroxide [$MgCO_3Mg(OH)_2$], followed by the addition of a weak acid such as phosphoric acid and a polymeric acid such as polymaleic acid. Initially, 1% aluminum hydroxide, 0.5% magnesium hydroxide or 1% magnesium carbonate hydroxide,

based on the dry weight of calcium carbonate, was added into a 20% solids slurry of ground calcium carbonate. The initial pH of calcium carbonate slurry was 8.01. After mixing, 1% phosphoric acid and 3% polymaleic acid, based on the dry weight of calcium carbonate, were added. A plot of the pH was measured for each sample from 28 to 93 hours ageing as shown in Figure 6. These treated calcium carbonate slurries all performed well in acid stability studies.

WHAT IS CLAIMED IS:

1. An acid resistant calcium carbonate comprising a mixture of at least about 0.1 percent, based on the dry weight of the calcium carbonate, of an aluminum or magnesium hydroxide together with at least about 0.1 percent, based on the dry weight of the calcium carbonate, of a mixture of two or more weak acids, in admixture with the calcium carbonate.

2. The acid resistant calcium carbonate of claim 1 wherein the aluminum or magnesium hydroxide is aluminum hydroxide.

3. The acid resistant calcium carbonate of claim 1 wherein the aluminum or magnesium hydroxide is magnesium hydroxide.

4. The acid resistant calcium carbonate of claim 1 wherein the aluminum or magnesium hydroxide is magnesium carbonate hydroxide.

5. The acid resistant calcium carbonate of claim 1 wherein the aluminum or magnesium hydroxide is present in an amount of about 1 to about 6 percent, based on the dry weight of the calcium carbonate.

6. The acid resistant calcium carbonate of claim 1 wherein the weak acids are selected from the group consisting of polyacrylate acid, polymaleic acid and phosphoric acid.

7. The acid resistant calcium carbonate of claim 6 wherein the mixture of weak acids includes at least one weak acid which is an organic, polymeric acid.

8. The acid resistant calcium carbonate of claim 6 wherein the mixture of weak acids is comprised of polyacrylate acid and phosphoric acid.

9. The acid resistant calcium carbonate of claim 6 wherein the mixture of weak acids is comprised of polymaleic acid and phosphoric acid.

10. The acid resistant calcium carbonate of claim 1 wherein the mixture of weak acids is present in an amount of about 1 to about 8 percent, based on the dry weight of the calcium carbonate.

11. A process for the preparation of an acid resistant calcium carbonate which comprises:

a) forming a mixture of calcium carbonate with at least about 0.1 percent, based on the dry weight of the calcium carbonate, of an aluminum or magnesium hydroxide;

b) adding at least about 0.1 percent, based on the dry weight of the calcium carbonate, of a mixture of two or more weak acids to the mixture ; and

c) blending the resultant mixture to ensure uniform mixing.

12. The process according to claim 11 wherein the weak acids of the mixture are selected from the group consisting of polyacrylate acid, polymaleic acid and phosphoric acid.

13. The process according to claim 12 wherein the mixture of weak acids includes at least one weak acid which is an organic, polymeric acid.

14. The process according to claim 11 wherein the mixture of weak acids is comprised of polyacrylate acid and phosphoric acid.

15. The process according to claim 11 wherein the mixture of weak acids is comprised of polymaleic acid and phosphoric acid.

16. The process according to claim 11 wherein the sodium carbonate is present in an amount of about 1 to about 6 per cent, based on the dry weight of the calcium carbonate.

17. The process according to claim 10 wherein the mixture of weak acids is present in an amount of about 1 to about 8 per cent, based on the dry weight of the calcium carbonate.

18. A method of improving the optical properties of neutral to weakly acidic paper by the addition of a calcium carbonate composition which comprises a mixture of at least about 0.1 percent, based on the dry weight of the calcium carbonate, of an aluminum or magnesium hydroxide together with at least about 0.1 percent, based on the dry weight of the calcium carbonate, of a mixture of two or more weak acids, in admixture with the calcium carbonate.

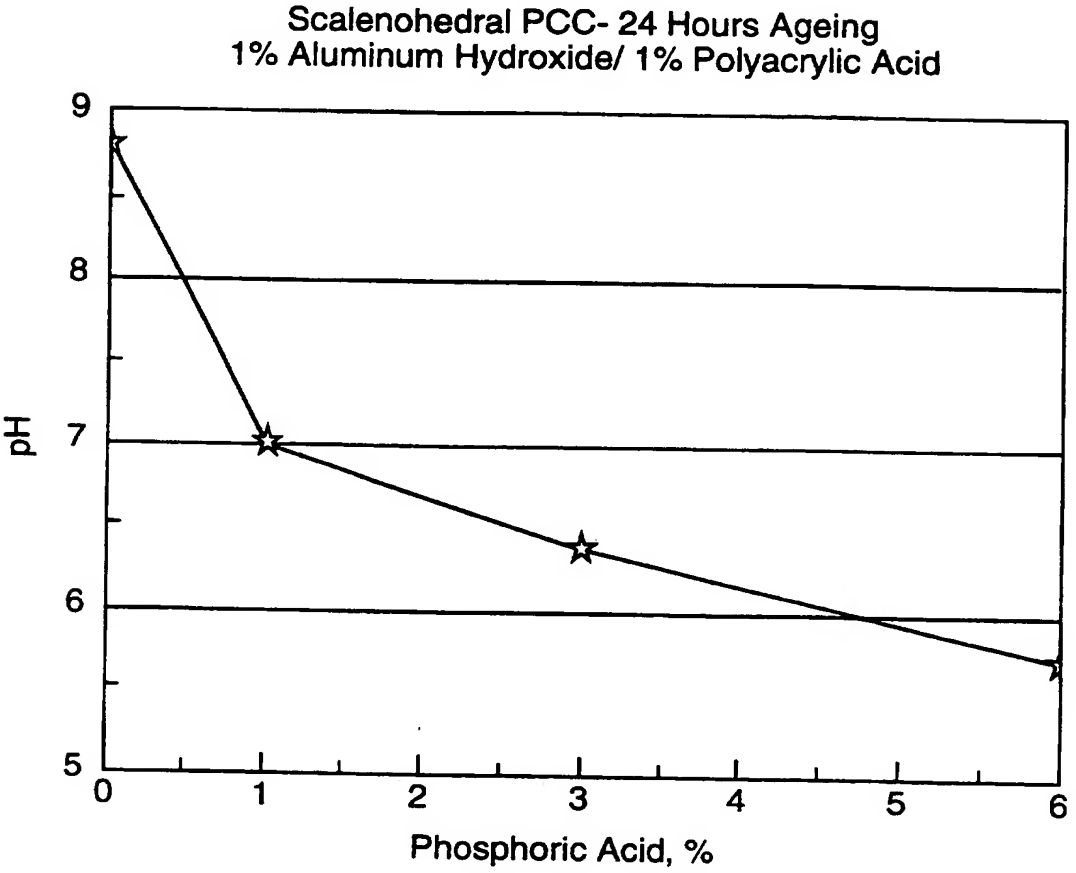

Scalenohedral PCC- 24 Hours Ageing
1% Aluminum Hydroxide/ 1% Polyacrylic Acid
pH
9
8
7
6
5
0
1
2
3
4
5
6
Phosphoric Acid, %

FIG. 1

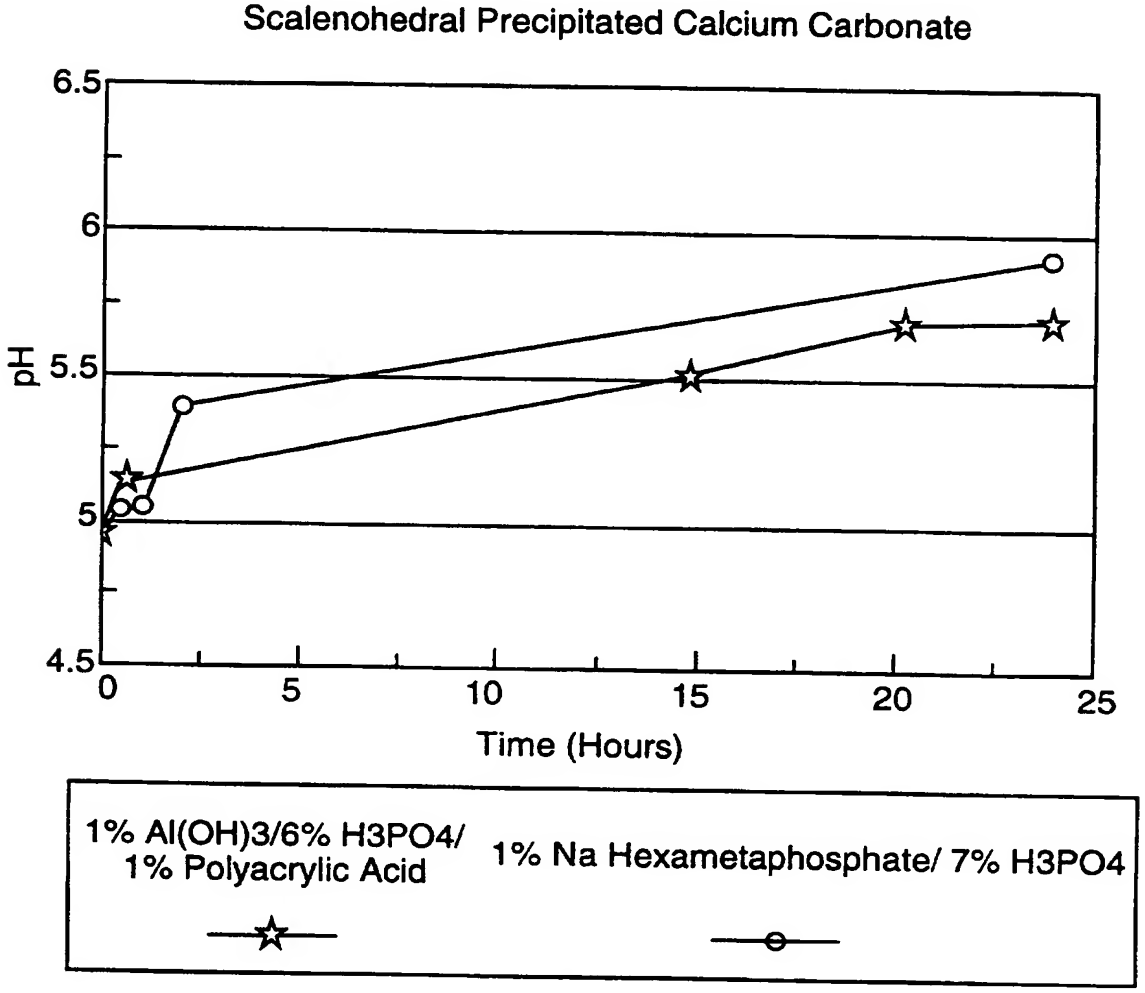

Scalenohedral Precipitated Calcium Carbonate
6.5
6
5.5
5
4.5
pH
0
5
10
15
20
25
Time (Hours)
1% Al(OH)3/6% H3PO4/
1% Polyacrylic Acid
1% Na Hexametaphosphate/ 7% H3PO4

FIG. 2

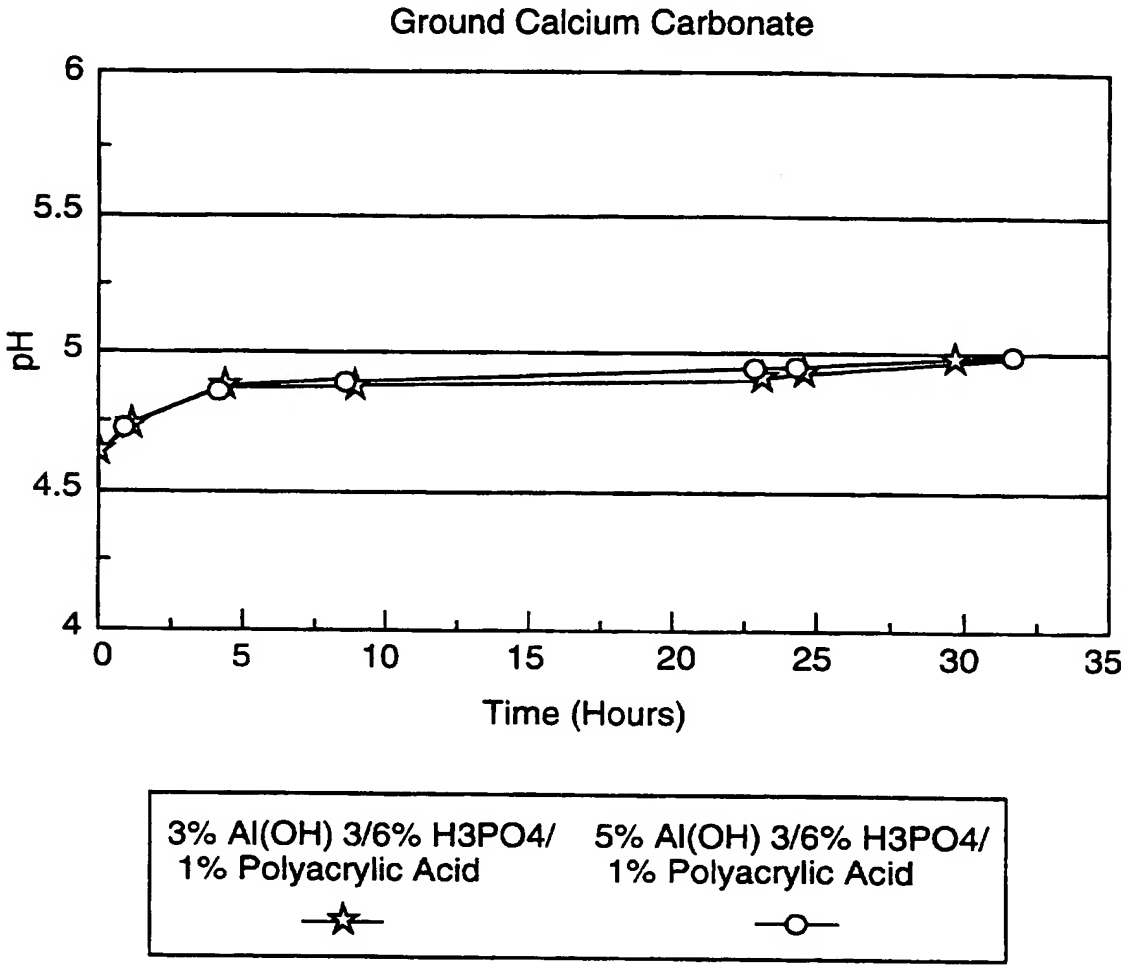

Ground Calcium Carbonate
6
5.5
5
4.5
4
pH
0
5
10
15
20
25
30
35
Time (Hours)
3% Al(OH) 3/6% H3PO4/ 1% Polyacrylic Acid
5% Al(OH) 3/6% H3PO4/ 1% Polyacrylic Acid

FIG. 3

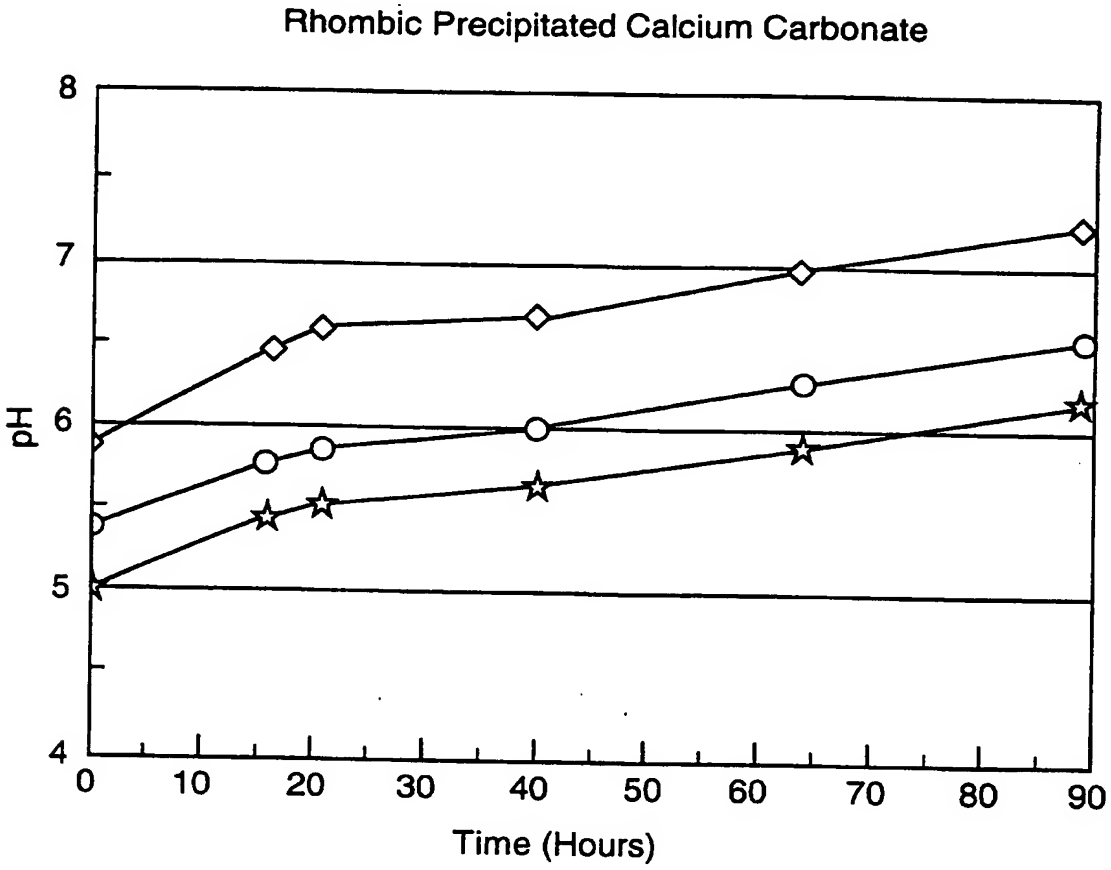

Rhombic Precipitated Calcium Carbonate
pH
8
7
6
5
4
0
10
20
30
40
50
60
70
80
90
Time (Hours)
0.5% MgCO3.Mg(OH)2/1% H3PO4/
1% Polyacrylic Acid
0.5% MgCO3.Mg(OH)2/3% H3PO4/
1% Polyacrylic Acid
0.5% MgCO3.Mg(OH)2/6% H3PO4/
1% Polyacrylic Acid

FIG. 4

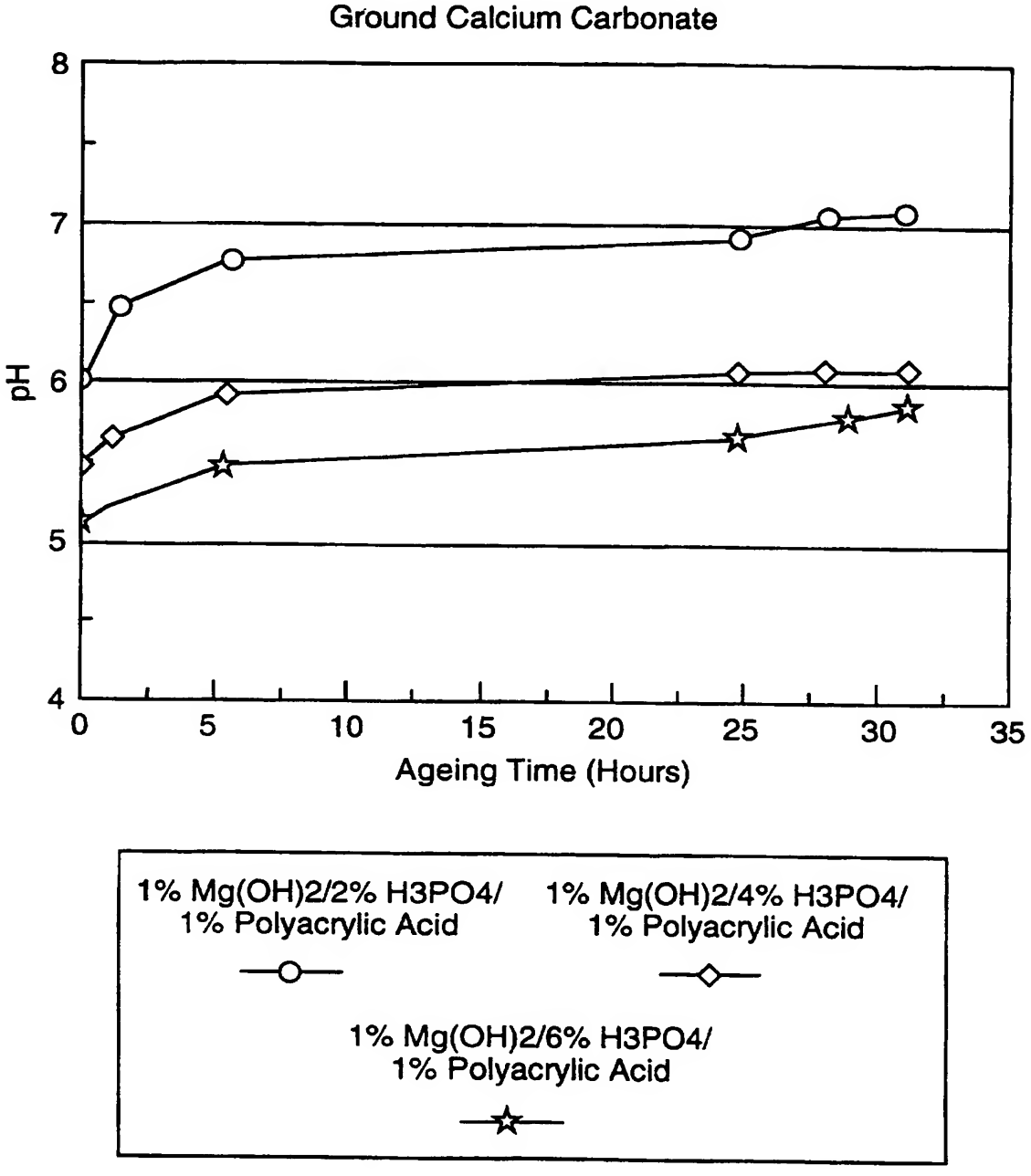

Ground Calcium Carbonate
8
7
6
5
4
pH
0
5
10
15
20
25
30
35
Ageing Time (Hours)
1% Mg(OH)2/2% H3PO4/
1% Polyacrylic Acid
1% Mg(OH)2/4% H3PO4/
1% Polyacrylic Acid
1% Mg(OH)2/6% H3PO4/
1% Polyacrylic Acid

FIG. 5

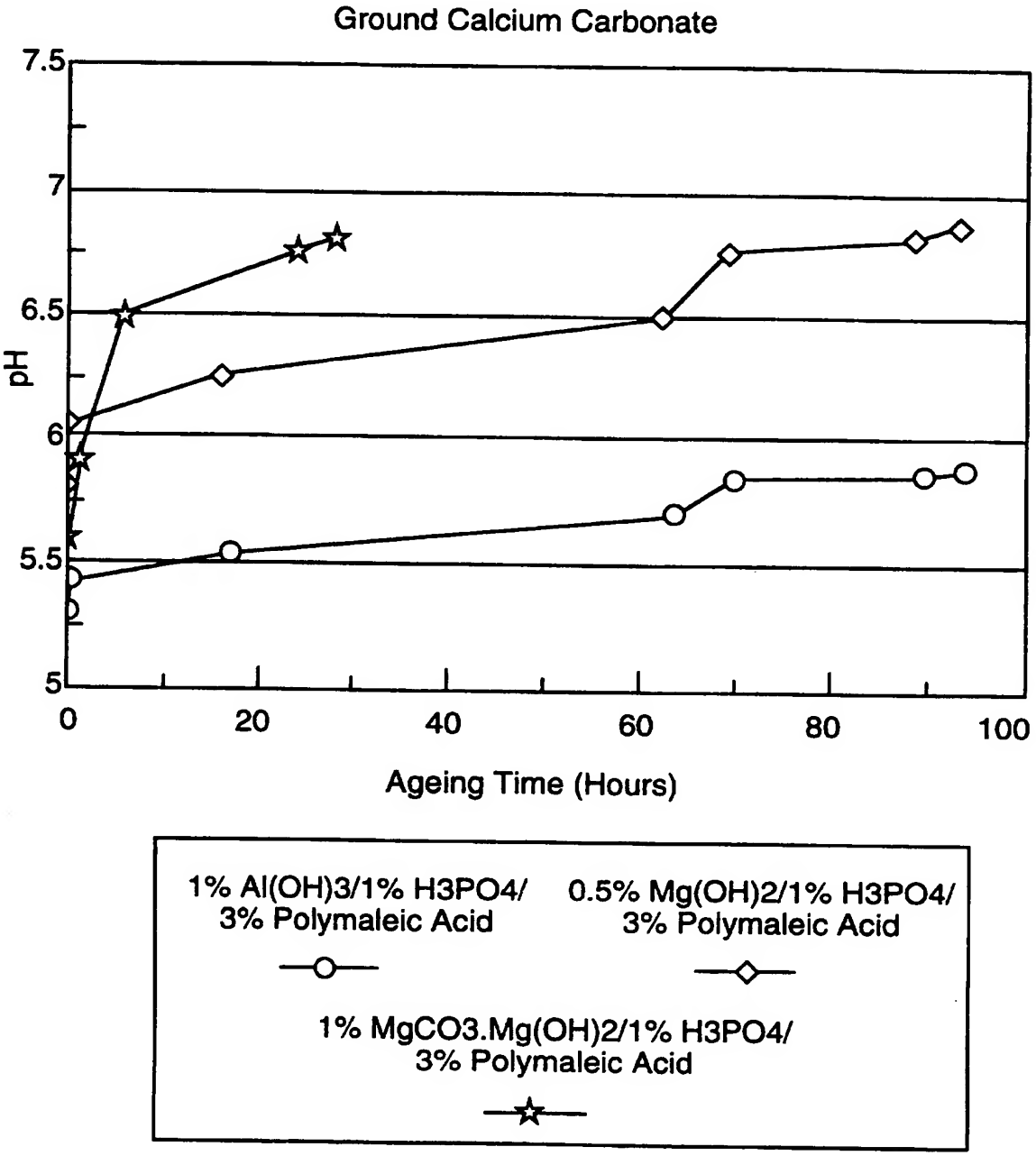

Ground Calcium Carbonate
7.5
7
6.5
6
5.5
5
pH
0
20
40
60
80
100
Ageing Time (Hours)
1% Al(OH)3/1% H3PO4/
3% Polymaleic Acid
0.5% Mg(OH)2/1% H3PO4/
3% Polymaleic Acid
1% MgCO3.Mg(OH)2/1% H3PO4/
3% Polymaleic Acid

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/16633

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :C09C 1/02; D21H 17/63, 17/64, 17/65, 17/67
US CL : 106/464, 465; 162/181.4; 423/420.2, 430
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 106/464, 465; 162/181.4; 423/420.2, 430

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,043,017 (PASSARETTI) 27 AUGUST 1991, COLUMN 4 LINE 9-COLUMN 6 LINE 20.	1-18
Y	US, A, 5,230,734 (KUMASAKA ET AL.) 27 JULY 1993, SEE THE ABSTRACT AND THE CLAIMS.	1-18
Y	US, A, 4,242,318 (BRAHM ET AL.) 30 DECEMBER 1980, COLUMN 1 LINE 58-COLUMN 2 LINE 53	1-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
19 NOVEMBER 1996

Date of mailing of the international search report
28 JAN 1997

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
Nirendra Roy
MICHAEL MARCHESCHI
Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)*